Recent observations and advances in solar wind turbulence

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The Wind spacecraft provides simultaneous solar wind velocity and magnetic field measurements with 3-second time resolution, roughly an order of magnitude faster than previous measurements, enabling the small scale features of solar wind turbulence to be studied in unprecedented detail. Almost the entire inertial range can now be explored (the inertial range extends from approximately 1 to 10^3 seconds in the spacecraft frame) although the dissipation range of the velocity fluctuations is still out of reach. Improved measurements of solar wind turbulence spectra at 1 AU in the ecliptic plane are presented including spectra of the energy and cross-helicity, the magnetic and kinetic energies, the Alfven ratio, the normalized cross-helicity, and the Elsasser ratio. Some recent observations and theoretical challenges are discussed including the observation that the velocity and magnetic field spectra often show different power law exponents with values close to 3/2 and 5/3, respectively; the energy (kinetic plus magnetic) and cross-helicity often have approximately equal power law exponents with values intermediate between 3/2 and 5/3; and the Alfven ratio, the ratio of the kinetic to magnetic energy spectra, is often a slowly increasing function of frequency increasing from around 0.4 to 1 for frequencies in the inertial range. Differences between high- and low-speed wind are also discussed. Comparisons with phenomenological turbulence theories show that important aspects of the physics are yet unexplained.